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Health and Ecological Effects of Energy Systems: An Overview

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Years ago, President Truman was briefed by the first chairman of the Council on Economic Advisers. Exercising the caution proper to his discipline, the chairman reputedly framed all his remarks in the context of such statements as, "On the one hand, *this might happen. But on the other hand, that might* happen." After an hour or so of this, following the economist's exit from the Oval Office, President Truman is said to have complained to an aide, "What we need around here is a one-handed economist."

This understandable impatience with ambiguity, and a craving for certainty even though all the facts are not in, characterizes most of us to some degree. It is particularly to be found in decision-makers, and it persists today. Several years ago, for example, Senator Muskie called for "one-armed scientists" after testimony from a number of them concerning the health effects of pollutants proved to be inconclusive. The decision-maker must act — and more and more, in our age, the decision-maker yearns for "facts" that will simplify difficult choices.

In a better world, perhaps the critical choices that we will have to make about energy in the next years and decades would await the findings of environmental scientists. No project would go on line before we knew precisely what it would do to human and environmental health, and before we had fashioned the proper safeguards.

But for lack of a better world, we are forced make do with the one we have — and in that world the production of energy appears to be the great global imperative. Under enormous pressure to ensure the production of ample and affordable supplies of energy, policy-makers will, in turn, press scientists for hard conclusions before any conclusions are justified by hard evidence. It would be simple to urge that we reject any such pressures in the interest of scientific purity — but in point of fact, we will probably have to accommodate those pressures. Except in *the face of the clearest, most definitely established* health and environmental hazards, energy development won't wait. The problem, then, is not one of standing on high principle, but of charting prudent strategy.

That means, first establishing research priorities. Prior to 1974, when the Federal Interagency Research Program was created, top priority was assigned to investigating and preventing the harmful health effects of coal burning. The rationale for this choice was logical and sound: our immense coal resources promised to make the most immediate contribution to our energy requirements, whereas other sources tended to be further off on the horizon. Hence it was thought the questions we would have to answer soonest were those related to coal consumption.

Now, however, the choice of priorities is becoming more difficult. Every technology has a probable time-line — a rough schedule, usually expressed in years, according to which successive stages of development will likely occur. Such a schedule, for example, might involve a shift from laboratory-scale tests of a new technology to the construction of a pilot facility; later on, from the pilot to a demonstration facility; and finally, from the construction of a demonstration facility to full-scale, commercial development.

Thus some decisions will have to be made now, *while others may not confront us for four, six, or* more years. Research priorities must be assigned in accordance with the probable development schedule for each technology; only thus can we ensure that, at

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every decision-point, the appropriate environmental research will also be available. If it is not, nonscientific pressures — including public demand for more energy, and political demand for action to satisfy the constituency — are likely to force a decision even on the basis of inadequate data. Judging by past experience, my hunch will be that energy development, not environmental and health protection, may have the benefit of the doubt.

Every energy technology being considered presents certain unknowns, and, if we had the leisure that science requires, we would insist that energy development wait until each of those unknowns was fully investigated. But we simply do not have the luxury of time. This pressure of time, together with limited resources, makes it impossible for us to examine these unknowns with all the thoroughness that each deserves. Relatively quick and inexpensive analysis may suggest that some negative environmental consequences are either so likely or so unlikely that additional R & D would not change the decision. Therefore, our environmental R & D should be directed toward those unknowns where the outcome is less clear, but potentially significant.

We must make maximum use of Federal leverage in energy development. Under normal circumstances, private enterprise would pay the bill for developing new energy technologies. But owing to the sensitivity of some of these technologies, the massive amounts of capital their development requires, and the national urgency of tapping new energy resources, the Federal government has agreed to underwrite some of the risk involved through such devices as direct support for demonstration.

This offers the opportunity to make close monitoring of environmental consequences an integral part of Federally supported energy development projects. At present, much of the data we have on emissions from new and emerging technologies is based on information from pilot plants and small-scale operations. The move from these small operations to commercial-sized demonstration plants gives us a unique opportunity to use these plants as environmental laboratories. We should take advantage of this opportunity, from the beginning of the R & D process, to prevent the creation of environmental "white elephants" — projects that later require huge investments in add-on control technology.

Another priority must be to correlate emissions and health affects. During the time I was Chairman of the Council on Environmental Quality, we pushed for the development of quantitative methods for estimating the environmental impacts of energy facilities. But we are still unable to translate a given quantity of pollutants into the number of cases of various human ailments that will result.

We must also bear in mind the fundamental interrelatedness of environmental impacts. Traditionally, scientists have broken their endeavors down into specific disciplines for their own convenience and hence have perceived reality from many different perspectives. Such specialization has been necessary for scientific and technological advance; and we have learned a great deal — and learned it quickly — by breaking phenomena down into various compartments and studying them from the standpoints of biology, physics, chemistry, and so forth. But we must remember that our world does not exist in compartments; it is comprised of single interrelated communities, each part of which affects every other part. While we pride ourselves in our perceptions of truth in our areas of specialty, we must widen them to include a holistic perspective.

This is a tall order. And it cannot be filled by one-handed scientists — by suppressing ambiguity in order to simplify decisions or to avoid the wrath of impatient decision-makers. Nor can it be filled by the leisurely pursuit of pure science. We are in a tough, nuts-and-bolts situation, and we must do the best we can to blend painstaking science with the sense or urgency that the national energy situation requires. Only by achieving this blend — by making haste carefully — can we hope to obtain the information we need when we need it.

The advent of an environmental consciousness is not a repudiation of our sciences, but a challenge to extend them. The environmental movement has taught us that man is not entirely master of his environment, but an integral part of it, and that he must learn to live in harmony with the natural world. In few respects is the achievement of that basic harmony more essential to the continued growth of civilized society than in our use of energy.

Let me cite a few of the potential health and ecological problems associated with energy technology.

Coal, America's most abundant of the fossil fuels, presents some of the greatest threats to human health and the environment. Let's consider some examples at different points in the coal fuel cycle. Coal miners are exposed to health hazards which surpass those of almost all other occupations. To make the problem more complex, the extent and severity of many of these hazards may not be apparent for 20 to 30 years after exposure. The greatest health threat to miners comes from coal dust, which is the cause of black lung disease. Currently, 15 to 20% of all underground miners, about 19,000, exhibit black lung disease to some degree. By the year 2000, this number is expected to reach 45,000. Since 1970, the U.S. has paid out, under the 1969 Coal Act, nearly $5.6 billion in benefits to 421,000 black lung disease victims who are disabled and unable to work, or to their survivors. Although major dust control programs are under way, there appears to be no way to substantially reduce or eliminate the disease. The price in human suffering to satisfy our coal needs in staggering.

Coal and its degradation products contain many compounds known to be carcinogenic. The several processes being developed for liquefaction and gasification of coal produce a wide variety of materials whose toxicity is little understood. Studies now under way will help to define the toxicity problems that might arise from the projected increased use of coal, but more remains to be done.

One of the most devastating examples of environmental hazards from the burning of coal is acid rain. Rain is normally slightly acidic because it contains dissolved carbon dioxide. The rainfall in several key areas of the world, however, has shown much higher acidity. Scandinavian lakes are being ruined and their fish populations wiped out. Presumably the acidity results from sulfur dioxide and nitrogen dioxide pollution from German and British industry. Half of the lakes in the Adirondacks have lost their entire fish population to acid rain that "originates" in the Ohio River Basin and elsewhere, and this problem is spreading. Essentially the entire Northeastern United States has been affected by acid rain. And, although we have considerable knowledge of the effect the acidification has on our lakes, we know little of its effect on the land. We do know that the production of some Northeastern forests has dropped, but there are too many other factors involved for us to be certain that acid rain is the sole cause.

Recently there has been considerable interest in coal slurry pipelines as a way to transport coal. Coal is ground into fine particles and slurried with a substantial amount of water so that it can be pumped through a pipeline. Currently, a coal slurry pipeline is in operation in the West and several other routes have been proposed. One would deliver coal from Wyoming to Texas with water coming from the Madison aquifer, a large underground water source in Montana, Wyoming, and the Dakotas. The vastness of this aquifer would lead one to believe at first glance that withdrawing water for the pipeline would do no measurable damage. However, closer examination reveals that this withdrawal, if concentrated in certain regions of the aquifer, could reduce its natural pressure to a point where the flow in existing wells would drop significantly. At best, this withdrawal would increase the cost of removing water for other purposes, such as irrigation, and at worst, would reduce the availability of water below the needed levels for other uses.

When coal seams are broken open and exposed to air and water, sulfuric acid is created. This is the source of the acid drainage that plagues mining operations and befouls streams, forest, and fields. To what extent this reaction occurs when coal is ground up and dispersed in water for transport through a pipeline with little oxygen present is unknown. Thus, what kind of disposal problem might arise at the end of the pipeline is also unknown. The Department of Energy is now funding a study of this potential problem.

As another example, let's look at the conversion of biomass to energy. Generally, this technology is regarded as having very positive environmental effects. This is particularly true in the case of fuel production from wastes, since it both solves the environmental problem of waste disposal and reduces the need to use more environmentally harmful fuels. On the other hand, large-scale energy farms, in which crops or trees are grown explicitly as a fuel, may cause severe adverse effects on the soil ecosystems by removing nutrients more rapidly than they can be replaced and by increasing the possibility of erosion. In addition, if large areas of new land are used for energy farming, considerable destruction of natural ecosystems — such as wildlife habitats and wilderness areas — may result.

Even energy conservation, as environmentally beneficial as it is, could cause health problems. For example, proposed standards for reducing air infiltration in houses to lower a home's heating and cooling load may reduce air changes in a typical house to a dangerous level. According to a recent study on the potential impact of such standards, toxic substances may accumulate to hazardous levels from such things as smoking. NO_x from unvented gas stoves and vapors from aerosols used in the home.

Perhaps the most serious problem we face is the potential buildup of CO_2 in the atmosphere from burning large quantities of fossil fuels. In 1956, Roger Revelle, an eminent marine geologist and former director of the Scripps Oceanographic Institution, observed that:

> "Human beings are carrying out a large-scale geophysical experiment of a kind that could not have happened in the past nor be repeated in the future. . . . Within a few centuries we are returning to the atmosphere and oceans the concentrated organic carbon stored in the sedimentary rocks over hundreds of millions of years. This experiment . . . may yield far-reaching insight into the processes determining weather and climate."

Now this is a most dispassionate way of saying that man, by burning enormous quantities of fossil fuels, is adding more carbon dioxide to the atmosphere than natural processes can removed. Measurements at Mauna Loa, Hawaii, over the last twenty years have shown a 6% increase in global CO_2 concentrations; many scientists believe that these concentrations will double between now and the first half of the 21st century. Carbon dioxide serves a very important function as the earth's temperature regulator. It is almost transparent to sunlight but fairly opaque to heat radiation, so that it acts very much as the windows in your car do when you leave them up on a sunny day. Add more CO_2 and the earth gets warmer, if all other things remain the same. Since things don't remain the same, we're faced with a complex modeling problem that our scientists haven't solved yet. You won't find too many climatologists out there, however, who don't think something significant is about to happen to the world's climate if we keep on increasing CO_2 levels. This may be the best reason anybody can think of to keep our energy options open and to accelerate our efforts in conservation.

There is simply no question that we are going to have to make dramatic changes in the way in which we consume and supply energy over the next few decades. The only real issue is whether the transition will be made in an orderly way to a long-term solution we can live with, or whether we will react with panic and confusion when the inevitable occurs and be forced to choose unattractive alternatives simply because we failed to make adequate plans when we had the time.

Our inability to deal adequately with our energy problems stems in part from the assumption by both the Federal government and major electric utilities that the solutions lie in more and more of the enormous centralized generating facilities which are providing an increasing share of our electric power. Once we make this assumption, it becomes largely self-perpetuating. To take an obvious example, the enormous Federal investments in developing, commercializing, fueling, insuring, protecting, and providing waste disposal for nuclear facilities have greatly accelerated the development of this technology with respect to possible competitors. The clear and continuing Federal commitment to the development of new centralized facilities has discouraged private investment in alternatives, created a large constituency of scientists, engineers, and investors which has developed its own political momentum, and generated vast Federal bureaucracies with an institutional interest in proving the wisdom of decisions they have made. Moreover, the size and complexity of new centralized plants mean that investors must be convinced to commit over a billion dollars to facilities which may not begin providing useful power for over a decade. These investors must somehow be assured that energy growth rates and consumption patterns will be maintained at predictable levels during the expected life of the plant. The need to protect these investments by assuring this demand could severely constrain our ability to make energy policy in the future.

One of the casualties of the assumption that energy will always be best provided by centralized facilities is an inability to think clearly about the advantages of the most environmentally benign energy technologies — solar energy and energy conservation. Both of these technologies work best when an attempt is made to match the energy resources to the immediate requirements of the buildings or industrial facilities served; they can be built quickly — usually as a part of the building served — and can be changed quickly to meet new energy needs. The implementation of these technologies will not require any profound reshaping of industrial, financial, or governmental institutions, since they can be built, financed, insured, and maintained by the kinds of organizations now providing similar services for heating and air conditioning equipment, for example. The technology is of a scale that permits concepts to be developed and brought to the market by many different kinds of organizations.

Competition in these technologies is feverish and probably always will be. Since the small technologies do not fit neatly into the competition for new centralized generating facilities, we have never developed a coherent plan for promoting them and have never funded them as serious long-term solutions to the energy problem. Supporting the decentralized technologies will not be easy and will require an unprecedented amout of imagination, flexibility and restraint on the part of policy-makers. But what would happen if the Federal government made a commitment to the development of small renewable energy sources equivalent to the commitment we made to develop fission two decades ago?

The advantages of the enormous energy resource which these solar and conservation technologies represent can only be properly understood if social and environmental issues are considered along with the technical ones. It will, however, probably be easier to resolve the technical questions associated with the development of new energy technologies than it will be to understand the ways in which they can be integrated into a society we would like to perpetuate. This difficulty must not deter us, however, since unless we are careful we may find ourselves in a position where we must adjust our society and institutions to fit the technologies which we develop instead of the other way around.

To help cope with this problem and to bring a more comprehensive and longer-range view to bear on their decision-making, the Congress six years ago established the Office of Technology Assessment, which I now head. It is our assignment to advise the Congress on the beneficial and adverse impacts of technological applications on social, environmental, economic and political factors.

We are currently carrying out a number of major studies that relate to the subject of this conference. They include the disposal of nuclear waste, the utilization of coal, alternative national energy futures, global energy trends, energy from biological processes, and the solar power satellite. Each will cover the health and ecological effects of the energy systems involved.

New energy technologies beckon us down many different roads with their promise of more of the abundant energy on which we have built our civilization. Yet their promise must not be permitted to blind us to the threat such development poses to our ecosystem on which man's very existence is built. It is up to us to determine as quickly as possible where each of these paths leads.

The distinguished geneticist, Theodore Bodzhansky, once remarked that: "Man and man alone knows that the world evolves and that he evolves with it. By changing what he knows about the world, man changes the world he knows; and by changing the world in which he lives man changes himself."

The energy choices the U.S. Congress and the country make over the next few years will radically change our world and ourselves. What we choose will be especially pertinent to the quality of life of our children and grandchildren. It behooves you and me to do all we can to see that the best choices are made.